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EVALUATION OF THE CURAEGIS MYCADIAN WATCH AND CURA TECHNOLOGY FOR DRIVER FATIGUE MANAGEMENT

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ABSTRACT:

As part of the technology evaluation of a driver fatigue management system, CurAegis's wristband-based fatigue monitoring system was evaluated in one logging contractor's fleet in the B.C. Interior. The drivers' feedback, sleep data, and alertness score were collected. The alertness score reported by the watch was compared and correlated with the driver's subjective fatigue score. The following is the study results and findings.

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INTRODUCTION

As a continuation of the evaluation of fatigue monitoring technologies (Shetty and Kohorst, 2017), FPInnovations, in collaboration with the BC Forest Safety Council, evaluated the myCadian watch, a CurAegis wristband-based fatigue monitoring technology. The Society of Behavioral Sleep Medicine (SBSM) provides some guidelines for minimum requirements (such as accelerometer data validated and published in a peer-reviewed journal) to consider wristband actigraphy-based technologies for research and clinical application (Ancoli-Israel et al., 2015). CurAegis's Circadian User Risk Assessment (CURA) technology was scientifically validated by a medical school in the US (Pigeon et al., 2018; Taylor et al., 2017), thus meeting the SBSM's minimum requirements for the technology to be considered for evaluation.

TECHNOLOGY DESCRIPTION

The myCadian watch, a product developed by CurAegis, collects physiological data and, using the CURA system, the app creates an alertness score called a CURA score. The CURA score is a 10-point scale that provides users with an estimate of their level of alertness throughout the day (Figure 1) as it varies with their sleep and circadian rhythm (CurAegis 2016). Higher values indicate the user has a high level of alertness, whereas lower values indicate a lower level of alertness. Sleep is one of the factors that relates to fatigue, so a user who receives an adequate amount of sleep, on a consistent schedule, should expect their scores to remain in the upper half of the scale, whereas a user who receives an inadequate amount of sleep should expect their scores to remain in the lower half of the scale. A 3 on the scale is roughly equivalent to the reaction time of a person with a 0.08 blood alcohol concentration (BAC)[1]. CurAegis's data collection monitors fatigue in real time which provides the potential to quantify the degree to which the wearer may be fatigued. Subsequently, the wearer could implement countermeasures and interventions, such as nap or exercise, in mitigating this impact.

The CURA system has three main elements:

- Real-time alertness monitoring using the myCadian watch;
- CURA software that provides a driver alertness score using a 10-point scale to help drivers assess the risk of alertness degradation (Figure 1); and
- Z-Coach® Wellness Program broken down into two parts: Z-Coach Education and Z-Coach Intervention.

The CURA system allows monitoring of driver fatigue in real time as long as a blue tooth connection with the device and cellular is established. Additional features are available such as the CURA Observation and Tracking System; CurAegis observes the dashboard and automatically notifies the fleet manager of drivers' status when the data from watch is synced with phone and phone is within cellular network or Wi-Fi coverage. Drivers are alerted

[1] The scaling was based on 28 hour sleep deprivation study (Payne-Rogers et. al. 2017).

in real-time of their level of alertness with audible alert and CURA score displayed on their watches when the score drops below threshold value.

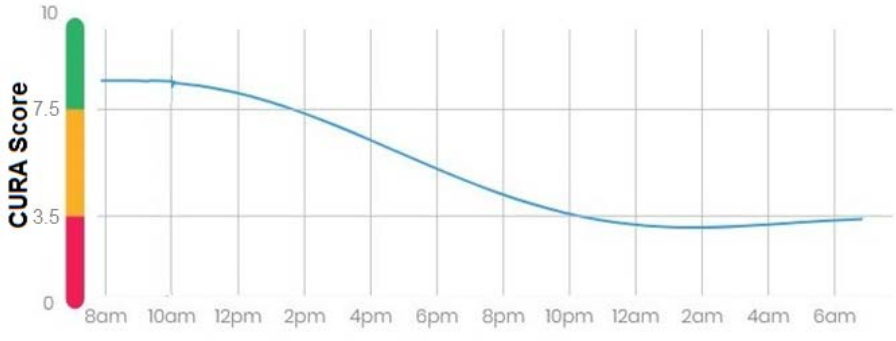


Figure 1. Sample variation of a subject's alertness score during the day (source: CurAegis).

CurAegis recommends scheduling day according to the CURA predictive graph, as the graph indicates the time when low alertness levels are likely to occur. Drivers or managers could implement fatigue management strategies accordingly if the low alertness level occurs during the work schedule. Countermeasures may include a nap, exercise, or consume caffeine at an optimum time in order to avoid a low score prior to or while on duty. Z-Coach teaches other fatigue mitigating techniques that might help drivers to adjust their habits over time. All this would help drivers achieve a higher CURA score with more consistency. CurAegis recommends managers use the CURA score to help plan the work schedule. The CURA claims the system gives managers tools to work with their drivers to help them make healthy choices and address sleep needs in a productive manner (Source: CurAegis FAQ).

OBJECTIVES

The objectives of this study were to:

- Evaluate CurAegis operational performance, acceptance, and usability in detecting and monitoring driver fatigue and implementing driver interventions;
- Verify the CurAegis Alertness Score with the Circadian Alertness Simulator (CAS) Fatigue Index.

METHODOLOGY

Nine drivers from a log hauling fleet in Interior B.C. participated in this study. The CurAegis firmware version was 0.1a and the application version was 1.3. CurAegis supported research project facilitators during the installation and training period, to ensure that drivers understood the technology and managers were able to effectively use the dashboard to retrieve information that would help guide them in driver intervention and coaching. An orientation session was conducted prior to the study; it provided an overview/explanation of the project and training pertaining to successful use of technology and associated data collection. Drivers were given a daily sleep and activity journal to complete in order to validate sleep periods, record the subjective Karolinksa Sleep scale prior to and at the end of the shift, record breaks, and track medication/caffeine use. In this study, participating drivers were kept anonymous and only fleet managers had access to the manager dashboard.

The study consisted of a baseline establishment stage, followed by an active fatigue management stage. Table 1 illustrates the monitoring elements for the test and control groups during the baseline establishment stage and the active fatigue management stage.

Table 1. Baseline establishment stage and active fatigue management stage elements

Elements	Baseline establishment stage	Active fatigue management stage
Number of drivers	9	9
Manager dashboard	No	Yes
Intervention	No	Yes
Sleep and fatigue level data collected	Yes	Yes
Duration	3 weeks (Dec. 18, 2017 – Jan. 7, 2018)	3 weeks (Jan. 8, 2018 – Jan. 26, 2018)

Baseline Establishment Stage: Initial fatigue level data was collected from nine drivers for three weeks without incorporating fatigue intervention. For this test, the manager dashboard and real-time driver alerts were turned off.

Active Fatigue Management Stage: The same group of drivers was monitored for another three weeks, during which fleet managers had access to the dashboard (Figure 2) and real-time driver alerts were activated. The group's average CURA scores for the baseline establishment stage and the active fatigue management stage were compared and the result of the complete study was presented as a percentage difference between the active fatigue management stage and the baseline establishment stage. Any intervention for the fatigued drivers, such as shortening shift duration, adjusting start times, taking a power nap, or having caffeine, was recorded. The managers' response to monitoring the test group's fatigue level through the manager dashboard was also recorded.

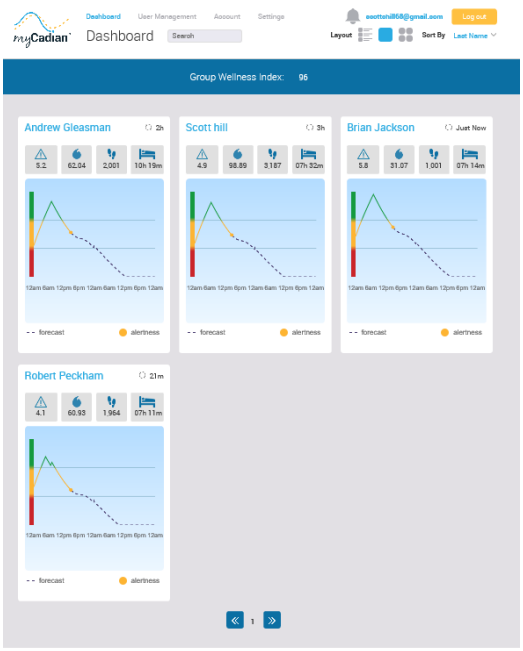


Figure 2. Sample manager dashboard (source: CurAegis).

CurAegis provided continuous CURA score raw data to FPInnovations for further analysis. Based on the data, the wristband-based fatigue detection system was evaluated. Feedback from drivers was also recorded.

The evaluation of technology covered the following areas:

- Ease of installation;
- Required training and ease of use;
- Driver acceptance;
- Technology reliability and performance; and
- Level of support from the technology provider.

To correlate and validate CurAegis's CURA score, a second scientifically validated system – the CAS software system (Moore-Ede et al., 2004) was used. CAS is a software program that calculates a person's fatigue risk level based on their sleep-wake history and individual profile. Drivers' sleep data and hours of service (work hours) were provided to Circadian Technologies Inc. to generate a CAS score profile for the participating drivers. The CAS score's fatigue risk level is categorized, as shown in Table 2.

Table 2. CAS fatigue risk levels (Circadian 2018)

Fatigue risk level	CAS score range	Zone
Low	0 – 30	Green
Average	31 – 60	Yellow
High	61 – 100	Red

Both the CURA score and the CAS score were correlated with the subjective score, the Karolinska Sleepiness Scale (KSS) that was recorded in the driver journal. Table 3 illustrates the KSS scale which drivers were asked to provide before the beginning of their shift and at the end of their shift.

Table 3. The Karolinska Sleepiness Scale (KSS) subjective score

KSS	Description
1	Extremely alert
2	Very alert
3	Alert
4	Rather alert
5	Neither alert nor sleepy
6	Some sign of sleepiness
7	Sleepy, but no effort to stay awake
8	Sleepy, some effort to stay awake
9	Very sleepy, great effort to stay awake

RESULTS

Operational Performance

Installation involved providing watches to the drivers and assisting drivers in downloading the app on their phone, entering the profile information for first time only, and syncing their watch with the app. This process takes about half an hour to an hour per driver, depending largely on the current status of the phone technology in use by the driver (software updates, email and 'app store' on phones etc.). The watch and app were relatively simple to use

and minimal training was required. The BC Forest Safety Council provided the driver and fleet manager orientation. The technology provider was available to assist and provided support via email and telephone when required.

Figure 3 shows the variation in the CURA score over the study period, with the shaded portion representing weekends and the unshaded portion weekdays. The baseline period included some holidays and short days during Christmas which may have had some influence on higher scores during the holiday period. The CURA alertness score between the baseline and active fatigue management periods shows no major change in the average score between two periods (Figure 4). The operations returned to full duty after the Christmas break.

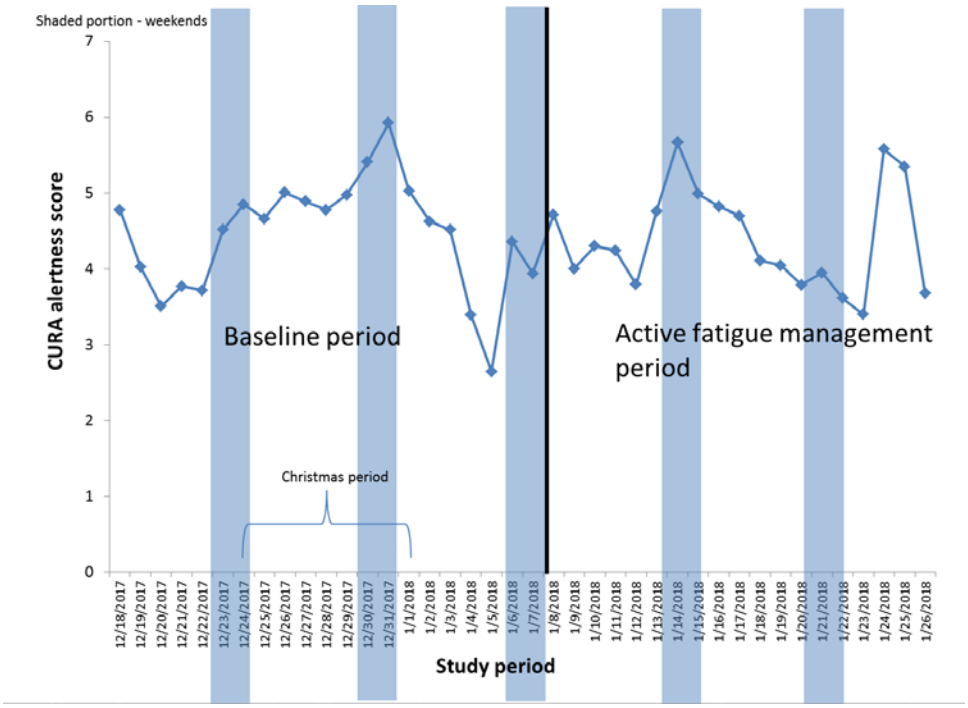
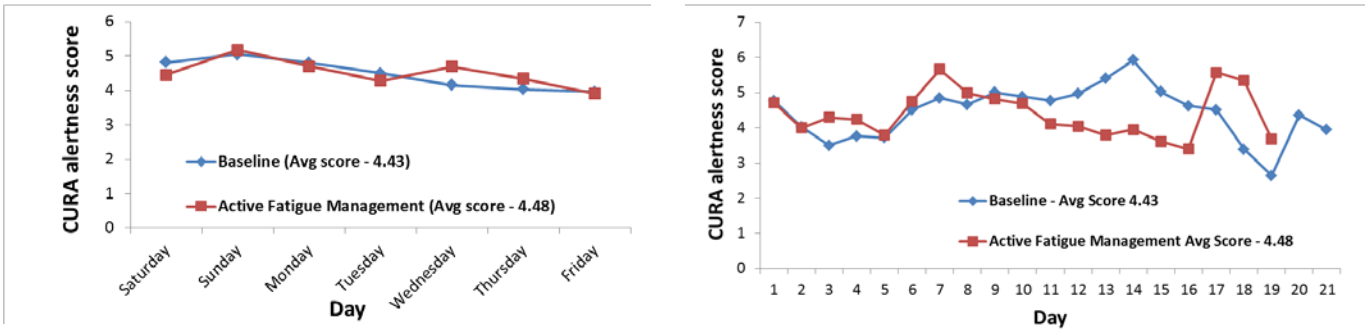


Figure 3. Average CURA score variation over the study period.



a) Variation through the week

b) Variation during two periods

Figure 4. Comparison of the CURA score between the baseline period and the active fatigue management period.

Technology Reliability

The myCadian watch's reliability in determining the alertness of the driver primarily depends on the CURA algorithm. The algorithm created the scores based on a combination of 16 biological, historical, and motion metrics. The watch is rugged, so no issues with non-functioning watches were reported during the study period.

The watch needed to be charged every couple of days. No phone battery draining due to syncing with the watch was reported during the study period. However, syncing the watch with the phone via Bluetooth was a major issue.

Implementing driver interventions would be dependent on real-time alerts to drivers as scores fall below the threshold value. Drivers reported real-time alerts during the active fatigue management period in their driver journal; however, most of them did not report any action taken as result of an alert. Real-time alertness score in the manager's dashboard is dependent on cell or Wi-Fi coverage and regularly syncing the watch with the phone. Due to the operating conditions (outside of cell coverage), this functionality was limited for the study.

CURA score reliability was assessed by comparing it with Circadian's CAS score. Table 4 presents the individual drivers' average CURA alertness score and CAS score for the month of January 2018. Driver #1's data was not compared due to incomplete dataset. The CAS score reported that drivers 5, 6, and 9 were in the high fatigue risk level and the CURA score reported that drivers 5 and 6 had low alertness levels that matched CAS score reporting; however, the CURA score reported that driver 9 had a moderate alertness level, which was an exception. Figure 5 shows some correlation between the CAS score and the CURA score, with a very low regression value (R^2) of 0.1025. The CAS score for a high fatigue risk factor correlates with the CURA score for a low alertness level and the CAS score for a low fatigue risk factor correlates with the CURA score a high alertness level.

Table 4. Individual driver alertness score comparison for January 2018

Driver	CURA score (0-3.5 low alertness level; 3.5-7.5 moderate alertness; 7.5-10 high alertness)	CAS score (Circadian, 2018) (0-30 low fatigue risk; 31-60 moderate risk; 61-100 high risk)
2	4.9	59.9
3	4.2	20.7
4	4.4	60
5	2.2	65
6	3.4	64.7
7	4.3	51.1
8	4.1	7.4
9	5.4	66.9

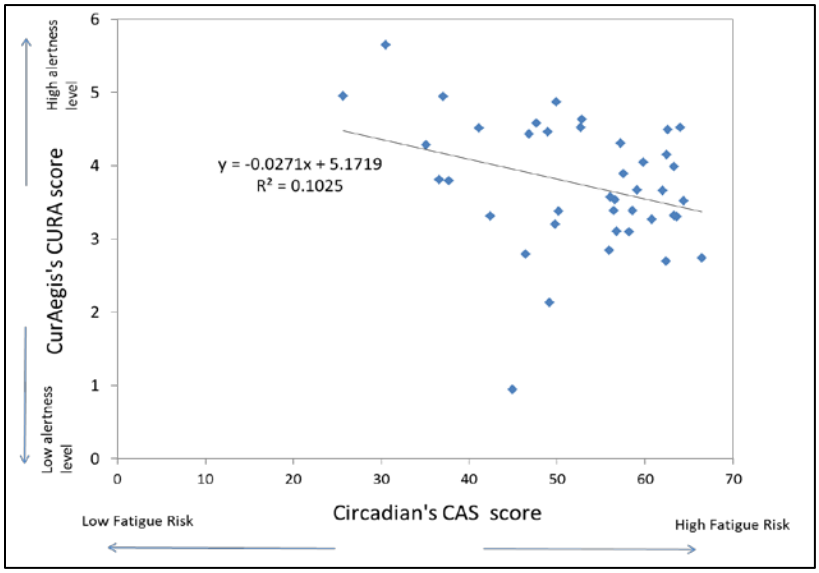


Figure 5. Correlation between Circadian's CAS score and CurAegis's CURA score.

The objective scores, CURA alertness score, and CAS fatigue risk score were correlated with the subjective KSS score (driver-reported score). Figure 6 shows the correlation between the objective scores and the subjective score. The correlation is weak, with a very low regression value. This is somewhat typical of the experience when using subjective scores, participants underestimate their level of fatigue.

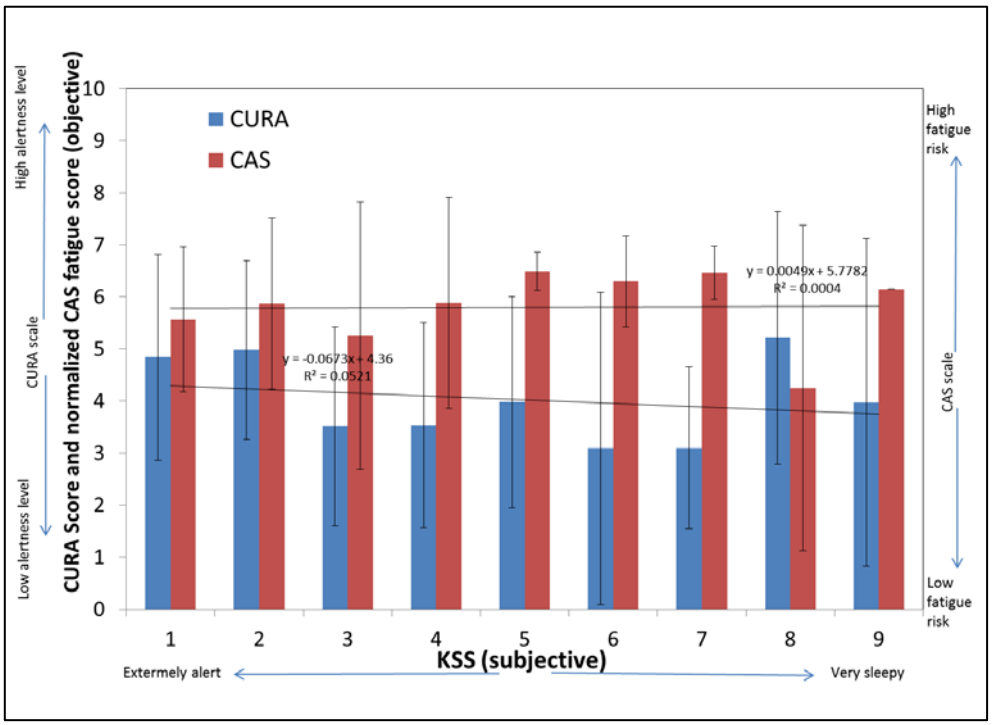


Figure 6. Correlation between the objective scores and the subjective score
(based on the average of beginning and end of driver shift scores over the study period).

Driver Acceptance

Drivers were surveyed at the end of the study for their feedback on the use of the watch and the app to manage fatigue. Table 5 summarizes the feedback received from the nine drivers. The feedback indicated that 75% of the drivers considered that the alertness score reported by the watch did not reflect how they felt. However, they somewhat liked the technology for monitoring and managing fatigue and found it easy to use. There were some syncing issues between the watch and the phone app.

One driver did not like the watch while working, while others found monitoring sleep activity enlightening and interesting.

In order to improve driver acceptance and system functionality, the syncing issue between the watch and the app needs to be addressed.

Table 5. Summary of drivers' responses to survey questions

Survey questions	No	Yes
Did the CurAegis fatigue monitoring watch help in managing fatigue?	88%	13%
Did the reported score reflect how you felt?	75%	25%
After the alert was activated, did your watch alert you when the score went below the threshold value?	25%	75%
Did CurAegis alerts distract you while driving?	88%	0%
Were the watch's warning signals and feedback adequate?	38%	63%
Have your sleeping habits changed as a result of wearing this watch?	88%	0%

Did you have any issues while charging the watch?	100%	0%
Did you have any issues syncing the watch with the app?	13%	88%
Were the app and dashboard user friendly?	13%	88%
Would you like training to learn more about the operation of this watch or app?	100%	0%
On a scale of 1 to 10 (1 being very difficult and 10 being very easy to use), rate the ease of use of this technology.	5.4 out of 10 (easy)	
On a scale of 1 to 10 (1 being highly disliked and 10 being highly liked), rate this technology for monitoring and managing fatigue.	4.9 out of 10 (somewhat liked)	
Did this technology improve your safety while driving?	100%	0%
Would you recommend all drivers wear this watch?	88%	13%

CONCLUSIONS

The myCadian watch was trialed in a logging fleet in Interior B.C., with nine drivers participating in the study. The main study findings were:

- There was not much difference in the average CURA score between the baseline and active fatigue management periods. Factors, such as hours of operation, season, and different scheduling, may have had influence on the results.
- The relationship between the CURA alertness score and the CAS fatigue index was poor, with very low regression value.
- The majority of the drivers reported syncing issues while connecting the watch with the phone app.
- Real-time actions from the safety manager require cell or Wi-Fi coverage and therefore in operations where coverage is not available, actions are solely dependent on drivers managing fatigue in real time.
- This technology requires further development in order for drivers to accept it. Addressing syncing issues between the watch and the app, may improve driver acceptance.

NEXT STEPS

The CurAegis myCadian watch is a relatively new product that is constantly evolving based on the feedback received. Since these tests started more than a year ago, FPInnovations followed up with CurAegis recently and learnt that they have changed their business model, discontinued their myCadian watch and are currently focusing on integration of their CURA technology with the popular off-the-shelf smart watches. The latest addition is CurAegis's CURA system designed for use with the FITBIT® Platform. Here is the link to FITBIT devices that are compatible with the CURA system http://www.CurAegis.com/CURA-Division/CURA-System/compatible-devices. The integration of the app with other off-the-shelf smart watches such as iPhone watch and all android based watches will be released soon. Since the myCadian app is reported to cost around US$27 per year, per driver (even cheaper US$3 to US$8 per year, per driver for higher volume), it might be worthwhile to re-evaluate this app with the new system to assess if the above-mentioned issues have been addressed. Proper planning, and support from drivers and fleets would be required for a meaningful re-evaluation.

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